INSTRUCTION MANUAL

EE181 Temperature and Relative Humidity Probe

Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific

- Batteries

- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.

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WHEN MEASUREMENTS MATTER

PLEASE READ FIRST

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area: 1 in^2 (square inch) = 645 mm^2

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in^2) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a "#" symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information

At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.

Precautions

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical
- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather
- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance
- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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Model EE181 Temperature and Relative Humidity Probe

1.   Introduction

The EE181 is a rugged, accurate temperature and relative humidity probe that is ideal for long-term, unattended applications in all climates. The probe uses an E+E Elektronik® capacitive RH element with a proprietary coating to measure relative humidity and a 1000 Ω PRT to measure temperature. For optimum results, the EE181 should be recalibrated annually.

For Edlog datalogger support, contact Campbell Scientific.

2.   Precautions

- READ AND UNDERSTAND the *Safety* section at the front of this manual.

- When opening the shipping package, do not damage or cut the cable jacket. If damage to the cable is suspected, consult a Campbell Scientific representative.

- Although rugged, the EE181 should be handled as a precision scientific instrument.

- Do not touch the sensor element.

- Santoprene® rubber, which composes the black outer jacket of the EE181 cable, will support combustion in air. It is used because of its resistance to temperature extremes, moisture, and UV degradation. It is rated as slow burning when tested according to U.L. 94 H.B. and passes FMVSS302. However, local fire codes may preclude its use inside buildings.

3.   Initial Inspection

- Check the packaging and contents of the shipment. If damage occurred during transport, immediately file a claim with the carrier. Contact Campbell Scientific to facilitate repair or replacement.

- Check model information against the shipping documents to ensure the expected products and the correct lengths of cable are received. Model numbers are found on each product. On cables and cabled items, the model number is usually found at the connection end of the cable. Report any shortages immediately to Campbell Scientific.

- Refer to Section 3.1, *Ships With (p. 2)*, to ensure that parts are included. The EE181 probe and its calibration card are shipped in a small box.

3.1 Ships With

The EE181 ships with:

(1) Calibration Card
(1) *ResourceDVD*

4. QuickStart

Short Cut is an easy way to program your datalogger to measure the EE181 and assign datalogger wiring terminals. *Short Cut* is available as a download on *www.campbellsci.com* and the *ResourceDVD*. It is included in installations of *LoggerNet*, *PC200W*, *PC400*, or *RTDAQ*.

Use the following procedure to get started.

1. Open *Short Cut*. Click **New Program**.
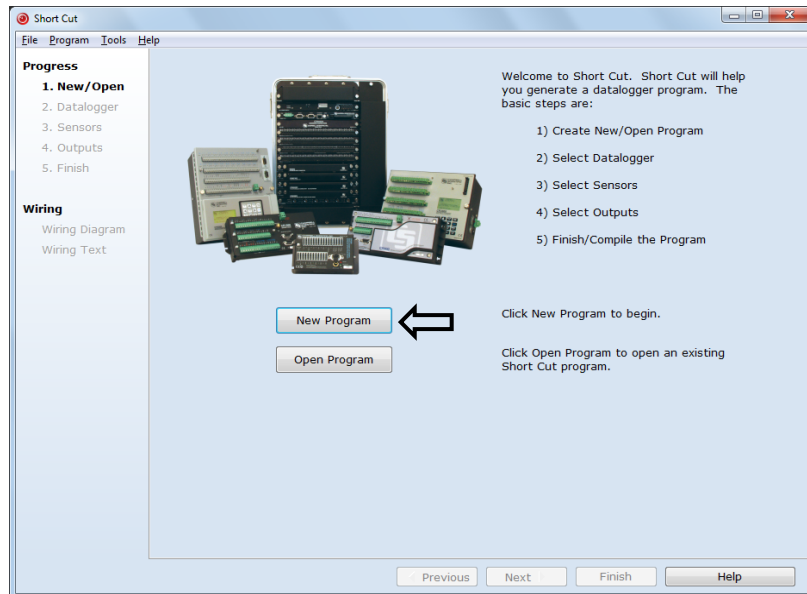
2. Select **Datalogger Model** and **Scan Interval** (default of **5** seconds is OK for most applications). Click **Next**.
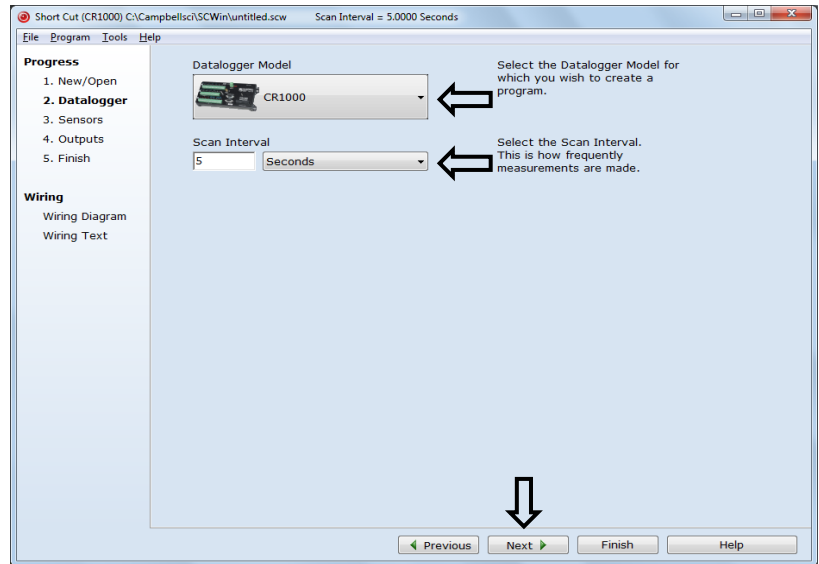
3. Under the **Available Sensors and Devices** list, select the **Sensors** | **Meteorological | Relative Humidity & Temperature | EE181 Temperature and Relative Humidity Sensor** folder. Choose either **constant power** or **panel switched power** (uses less current). Click to move the selection to the **Selected** device window. Data defaults to degree Celsius. This can be changed by clicking the **Deg C** box and selecting **Deg F**, for degrees Fahrenheit, or **K** for Kelvin.
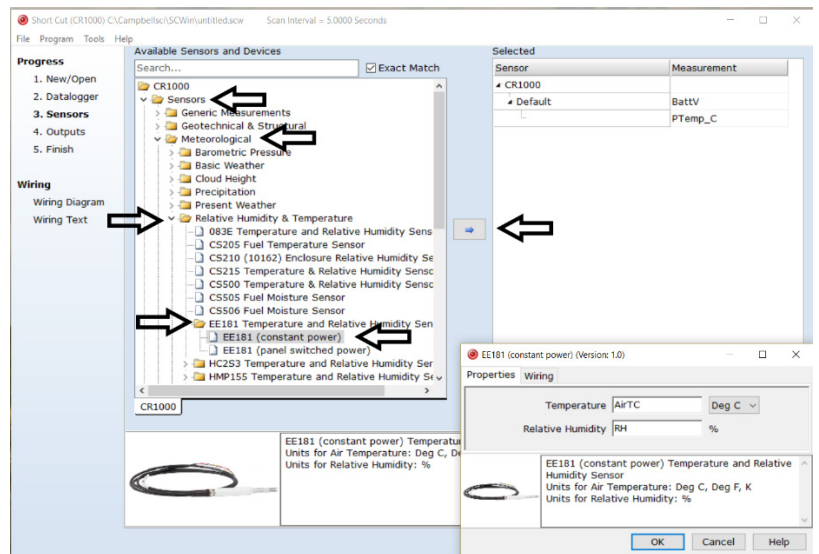
4. After selecting the sensor, click **Wiring Diagram** to see how the sensor is to be wired to the datalogger. The wiring diagram can be printed now or after more sensors are added.
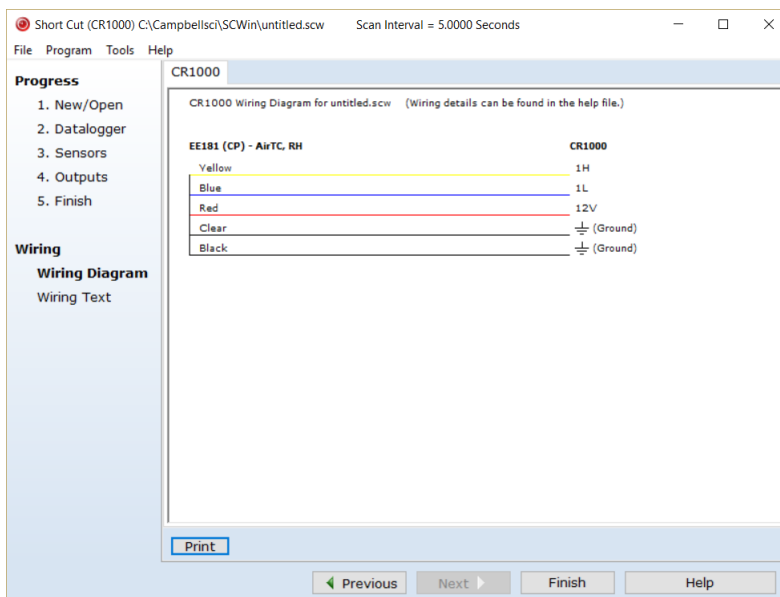
5. Select any other sensors you have, then finish the remaining *Short Cut* steps to complete the program. The remaining steps are outlined in *Short Cut Help*, which is accessed by clicking on **Help | Contents | Programming Steps**.

6. If *LoggerNet, PC400, RTDAQ,* or *PC200W* is running on your PC, and the PC-to-datalogger connection is active, you can click **Finish** in *Short Cut* and you will be prompted to send the program just created to the datalogger.

7. If the sensor is connected to the datalogger, as shown in the wiring diagram in step 4, check the output of the sensor in the datalogger support software data display to make sure it is making reasonable measurements.

5.   Overview

The EE181 is a digital probe with linear voltage outputs for temperature and humidity. Its voltage signals are measured with two single-ended inputs on the datalogger.

Campbell Scientific recommends 12 V power when used with our dataloggers. When minimizing power use is important, power can be switched on and off for the measurement, provided there is a two-second warm-up delay. Switching power avoids constant current flow through datalogger ground, which can affect the accuracy of low-level single-ended voltage measurements.

The EE181 uses a metal mesh filter with excellent response, protection against dust, and no water absorption.

6.   Specifications

Features:

- Well-suited for long-term, unattended applications
- Accurate and rugged
- Compatible with the following CRBasic dataloggers: CR200(X) series, CR300 series, CR6 series, CR800 series, CR1000, CR3000, CR5000, CR9000(X)

Operating Limits:	–40 to 60 °C
Storage Temperature:	–40 to 80 °C
Probe Length:	160 mm (6.3 in), 172 mm (6.77 in) including connector
Probe Diameter:	21 mm (0.83 in)
Weight with 5 m Cable:	290 g (10.2 oz)
Housing:	Plastic material / IP65
Filter:	30 µm pore size, stainless steel mesh
Power Consumption:	<1.2 mA at 12 V
Supply Voltage (using CSI cable):	7 to 30 Vdc (12 Vdc recommended)
Start-Up Time:	2 s typical
Maximum Cable Length:	300 m (1000 ft) with 12 V power

Analogue outputs
Offset at 0 V:	±3 mV (maximum)
Deviation from Digital Signal:	< ±1 mV (0.1 °C, 0.1% RH)

Compliance:	View the EU Declaration of Conformity at *www.campbellsci.eu/ee181-l*

6.1   Temperature Measurement

Sensor:	Pt1000 Class A
Measurement Range:	–40 to 60 °C
Output Signal Range:	0 to 1.0 V
Accuracy at 23 °C:	±0.2 °C
Long Term Stability:	<0.1 °C/year

**Sensor Time Constant
[63% step change (1 m/s air
flow at sensor)]**

Standard PE Filter:		≤22 s
Optional Teflon Filter:		≤30 s

Accuracy over Measurement Range:
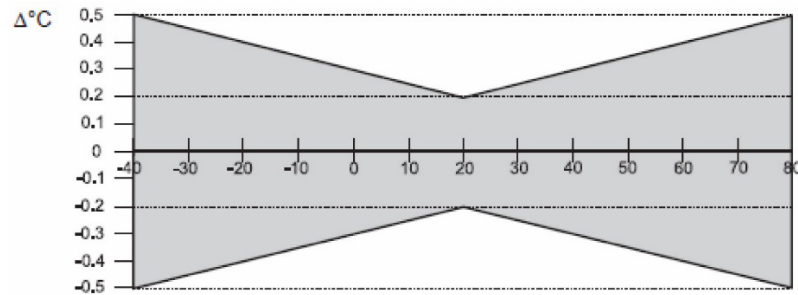
6.2   Relative Humidity Measurement

Sensor:	HC101
Measurement Range:	0 to 100% non-condensing
Output Signal Range:	0 to 1.0 Vdc

Accuracy*
(including hysteresis, non-linearity
and repeatability, traceable to
international standards,
administrated by NIST, PTB, BEV)

–15 to 40 °C:	≤90% RH	± (1.3 + 0.003 • RH reading) % RH
–15 to 40 °C:	>90% RH	± 2.3% RH
–25 to 60 °C:		± (1.4 + 0.01 • RH reading) % RH
–40 to 60 °C:		± (1.5 + 0.015 • RH reading) % RH

Typical Long-Term Stability:	<1% RH per year

Sensor Time Constant [63% of a
35 to 80% RH step change
(1 m/s air flow at sensor)]

Standard PE Filter:	≤22 s
Optional Teflon Filter:	≤30 s

* The accuracy statement includes the uncertainty of the factory calibration with an enhancement factor k=2 (2-times standard deviation).

The accuracy was calculated in accordance with EA-4/02 and with regard to GUM (Guide to the Expression of Uncertainty in Measurement).

7.   Installation

If you are programming your datalogger with *Short Cut*, skip Section 7.1, *Wiring to Datalogger* *(p. 7)*, and Section 7.2, *Datalogger Programming* *(p. 7)*. *Short Cut* does this work for you. See Section 4, *QuickStart* *(p. 2)*, for a *Short Cut* tutorial.

7.1   Wiring to Datalogger

Connections to Campbell Scientific dataloggers for measuring humidity and temperature using two single-ended analog inputs are given in TABLE 7-1. See Section 8.3, *Long Cable Lengths (p. 11)*, for a discussion on errors caused by long cable lengths.

<table>
<tr><td colspan="3" align="center">TABLE 7-1. Wire Colour, Function, and Datalogger Connection
for Single-Ended Measurement</td></tr>
<tr><td align="center">Wire
Colour</td><td align="center">Wire Function</td><td align="center">Datalogger Connection Terminal</td></tr>
<tr><td>Yellow</td><td align="center">Temperature signal</td><td>U configured for single-ended analogue input[1], SE (single-ended, analogue-voltage input)</td></tr>
<tr><td>Blue</td><td align="center">Relative humidity signal</td><td align="center">U configured for single-ended analogue input, SE</td></tr>
<tr><td>Black</td><td align="center">Signal reference</td><td align="center">⏚
(analogue ground)</td></tr>
<tr><td>Clear</td><td align="center">Shield</td><td align="center">⏚</td></tr>
<tr><td>Red</td><td align="center">Power</td><td align="center">12V or SW12V</td></tr>
<tr><td colspan="3">[1]U channels are automatically configured by the measurement instruction.</td></tr>
</table>

7.2   Datalogger Programming

Short Cut is the best source for up-to-date datalogger programming code. Programming code is needed when:

- Creating a program for a new datalogger installation
- Adding sensors to an existing datalogger program

If your data acquisition requirements are simple, you can probably create and maintain a datalogger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

NOTE   *Short Cut* cannot edit programs after they are imported and edited in *CRBasic Editor*.

A *Short Cut* tutorial is available in Section 4, *QuickStart (p. 2)*. If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in Appendix A, *Importing Short Cut Code Into CRBasic Editor (p. A-1)*. Programming basics for CRBasic dataloggers are provided in the following sections. A complete program example for a select datalogger can be found in Appendix B, *Example Programs (p. B-1)*.

7.2.1 VoltSE() Instruction

The **VoltSE()** measurement instruction is used with CRBasic dataloggers to measure both temperature and relative humidity from the EE181 sensor. The

output scale is 0 to 1000 mV for the temperature range of –40 to 60 °C and 0 to 1000 mV for the relative humidity range of 0 to 100%.

```
VoltSE(Dest, Reps, Range, SEChan, MeasOff, SettlingTime,
Integ/FNotch, Mult, Offset)
```

Variations:

- Temperature reported as °C — set **Mult** to **0.1** and **Offset** to **-40**

- Temperature reported as °F — set **Mult** to **.18** and **Offset** to **-40**

- Humidity reported as a percent – set **Mult** to **0.1** and **Offset** to **0**

- Humidity reported as a fraction – set **Mult** to **0.001** and **Offset** to **0**

NOTE	When the probe is connected to a CS110 Electric Field Meter, the probe is measured by the CS110's internal CR1000 datalogger module using **VoltSE()** instructions. Relative humidity and temperature signals are measured on single-ended channels 1 and 2, respectively. 250 μs integration should be used in the **VoltSE()** instructions.

7.3   Field Installation

Sensors should be located over an open, level area at least 9 m (EPA) in diameter. The surface should be covered by short grass or the natural earth surface where grass does not grow. Sensors should be located at a distance of at least four times the height of any nearby obstruction and at least 30 m (EPA) from large, paved areas. Sensors should be protected from thermal radiation and adequately ventilated. Protect the filter at the top of the sensor from exposure to liquid water. The hydrophobic nature of the filter repels light rain, but driving rain can force itself into the pore structure of the filter and take time to dry out.

Standard measurement heights:

> 1.5 m (AASC 1985)
> 1.25 to 2.0 m (WMO 2008)
> 2.0 m (EPA 2008)

See Section 10, *Attributions and References (p. 13)*, for a list of references that discuss temperature and relative humidity sensors.

When used in the field, the EE181 must be housed in a radiation shield such as the RAD10E naturally aspirated shields.

The white colour of these shields reflects solar radiation, and the louvered construction allows air to pass freely through, thereby keeping the probe at or near ambient temperature. The RAD10E uses a double-louvered design that offers improved sensor protection from insect intrusion and driving rain and snow. In addition, the RAD10E shield has lower self-heating in bright sunlight combined with higher temperatures (> 24 °C (75 °F)) and low wind speeds (< 2 m/s (4.5 mph)), giving a better measurement.

The RAD10E radiation shield attaches to a crossarm, mast, or user-supplied pipe with a 2.5 to 5.3 cm (1.0 to 2.1 in) outer diameter. See FIGURE 7-2 for an example of shield mounting.

The optimal location for the EE181 sensor tip inside a multi-plate shield is approximately 1/3 to 1/2 of the way down from the top shield plate. With a ten-plate shield, the tip of the EE181 should be located around three to four plates down from the top of the shield. See FIGURE 7-1.
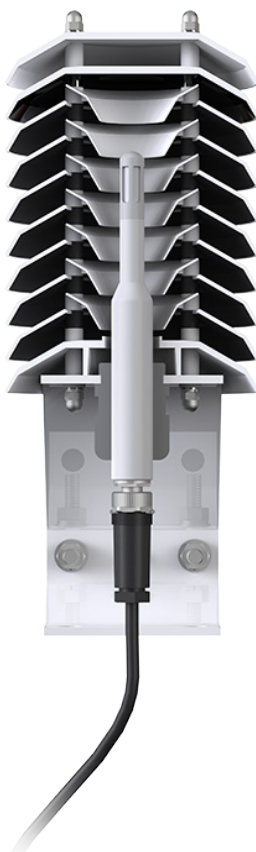
FIGURE 7-1. EE181 Sensor Placement in a RAD10E Multi-plate Shield

Tools required for installing an EE181 sensor in a radiation shield to a tripod or tower include:

- 1/2 inch open-end wrench
- small screwdriver provided with datalogger
- UV-resistant cable ties
- small pair of diagonal-cutting pliers
- adjustable wrench with a minimum 1-7/8 inch jaw size

Attach the probe to the cable by aligning the keyed connectors, pushing the connectors together, and finger tightening the knurled ring.

CAUTION	Only finger tighten the knurled ring. Using a wrench may damage the connector.

7.3.1 Shield Installation

It is recommended to use the EE181 with the MetSpec RAD10E multi-plate radiation shield due to shield performance in bright sunlight and low wind speeds as well as over snow or reflective surfaces. The EE181 will work with the RM Young 10-plate shield but requires a special adapter (pn #28415) to accommodate sensor girth.

7.3.1.1 *Installation in a RAD10E 10-Plate Shield*

NOTE	Do not mount the shield or route the sensor cable into the enclosure until after the EE181 is installed inside the shield.

1. Loosen the sensor gland nut on the bottom of the shield.

2. Insert sensor into the bottom of the multi-plate shield. Situate the gland so it's 1/2 inch to 1 inch above the sensor connector. See FIGURE 7-1.

3. Tighten the nut around the gland until it firmly grips the body of the probe. Use an adjustable wrench if necessary, but do not overtighten the nut.

7.3.1.2 *Installation in an RM Young 41003-5 10-Plate Shield*

NOTE	Do not mount the shield or route the sensor cable into the enclosure until after the EE181 is installed inside the shield.

1. Slide the adapter over the sensor body and situate the adapter so it's 1/2 inch to 1 inch above the sensor connector.

2. Insert sensor and adapter into the bottom of the multi-plate shield.

3. Hold the collar and sensor and finish threading the collar into the shield by hand. Tighten the collar around the probe until it firmly grips the body of the probe. Use an adjustable wrench if necessary, but do not overtighten the collar.

7.3.2 Mount the Shield

1. Attach the radiation shield to the tripod mast, crossarm, or tower leg using the supplied U-bolt. See FIGURE 7-2 for an example of shield mounting.

2. Route the cable to the datalogger, and secure the cable to the mounting structure using cable ties.

*FIGURE 7-2. EE181 and RAD10E Solar Radiation Shield on a tripod
mast*

8. Operation

8.1 Measurement

The probe uses E+E Elektronik's coated HC101 capacitive sensor to measure
RH and a 1000 Ω PRT to measure temperature. Campbell Scientific
dataloggers measure the analog voltage outputs of the EE181 Temperature and
Relative Humidity Probe with the **VoltSE()** measurement instruction.

8.2 Low Power Operation

The EE181 draws less than 1.2 mA powered from 12 V. The EE181 can be
continuously powered from the **12V** terminal, or power can be switched with
the **SW12V** terminal to conserve battery life. When power is switched, a two-
second warm-up period is required. This is programmed with the **Delay()**
instruction, using 0 for the delay option.

8.3 Long Cable Lengths

Long lead lengths cause errors in the measured temperature and relative
humidity. The approximate error in temperature and relative humidity is
0.31 °C and 0.31% per 100 feet of cable length, respectively.

When long lead lengths are required and the above errors in temperature and
relative humidity are unacceptable, use the HC2S3 or HMP155A temperature
and relative humidity probe.

Understanding the following details are not required for the general operation
of the EE181 with Campbell Scientific's dataloggers. The signal reference and
the power ground (black) are the same lead in the EE181. When the EE181

temperature and relative humidity are measured, both the signal reference and power ground are connected to ground at the datalogger. The signal reference/power ground lead serves as the return path for 12 V. There will be a voltage drop along this lead because the wire itself has resistance. The EE181 draws approximately 1.2 mA (worst case) when it is powered. The wire used in the EE181 (pn #9721) has resistance of 25.67 Ω/1000 feet. Using Ohm's law, the voltage drop (V_d), along the signal reference/power ground lead, is given by Eq. (1).

$$
\begin{aligned}
V_d &= I \bullet R \\
&= 1.2 \text{ mA} \bullet 25.67 \ \Omega/1000 \text{ ft} \\
&= 30.804 \text{ mV}/1000 \text{ ft}
\end{aligned}
\tag{1}
$$

This voltage drop will raise the apparent temperature and relative humidity because the difference between the signal and signal reference at the datalogger has increased by V_d.

9.   Toubleshooting and Maintenance

NOTE	All factory repairs and recalibrations require a returned materials authorization (RMA) and completion of the "Declaration of Hazardous Material and Decontamination" form. Refer to the *Assistance* page at the beginning of this manual for more information.

9.1   Troubleshooting

Symptom: Relative Humidity is reported as **–9999**, **NAN**, **–40 °C**, or **0 %**

1.   Check that the sensor is wired to the correct analogue input channels as specified by the measurement instructions.

2.   Verify the voltage range code for the single-ended measurement instruction is correct for the datalogger type.

3.   Verify the red power wire is connected to the **12V** or **SW12V** terminal.

4.   A voltmeter can be used to check the output voltage for temperature and relative humidity on the brown and white wires respectively (temperature°C = mV • 0.1 – 40.0; relative humidity % = mV • 0.1).

Symptom: Incorrect temperature or relative humidity

1.   Verify the multiplier and offset parameters are correct for the desired units (Section 7.2.1, *VoltSE() Instruction (p. 7)*) and temperature range.

9.2   Maintenance

The EE181 probe requires minimal maintenance, but dust, debris, and salts on the filter cap will degrade sensor performance. Check the metal mesh filter on the end of the sensor for debris. If dirt or salt is engrained into the filter, it should be cleaned with distilled water or replaced. For particularly stubborn contamination, swish the entire probe tip in isopropyl alcohol (rubbing alcohol)

and rinse off with distilled water. Make sure the filter is connected firmly with your fingers — do not over tighten.

Check the radiation shield monthly to make sure it is free from dust and debris. To clean the shield, remove the sensor from the shield. Dismount the shield. Brush all loose dirt off. If more effort is needed, use warm, soapy water and a soft cloth or brush to thoroughly clean the shield. Allow the shield to dry before remounting.

Replace filters that cannot be successfully cleaned. To replace the filter, unscrew the filter from the probe and pull it straight away, being careful not to bend or damage the sensors. Before putting on the replacement filter, check the alignment of the sensors with the probe, and if necessary, carefully correct the alignment before installing the filter.

A coating of salt (mostly NaCl) may build up on the radiation shield, sensor, filter and even the sensor element. A buildup of salt on the filter or sensors will delay or destroy the response to atmospheric humidity.

Long-term exposure of the relative humidity sensor to certain chemicals and gases may affect the characteristics of the sensor and shorten its life. The resistance of the sensor depends strongly on the temperature and humidity conditions and the length of the pollutant influence.

The sensor should be calibrated annually. Please obtain an RMA number before returning the EE181 to Campbell Scientific for calibration. Please refer to the *Limited Warranty* and *Assistance* sections at the beginning of the manual.

10. Attributions and References

E+E Elektronik® is a registered trademark of E+E Elektronik Ges.m.b.H.

Santoprene® is a registered trademark of Exxon Mobile Corporation.

AASC, 1985: The State Climatologist (1985) Publication of the American Association of State Climatologists: *Heights and Exposure Standards for Sensors on Automated Weather Stations*, v. 9, No. 4 October, 1985. (www.stateclimate.org/publications/state-climatologist/NOAA-NCY-SCBOOKS-SC77097/00000029.pdf)

EPA, 2000: *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

EPA, 2008: *Quality Assurance Handbook for Air Pollution Measurement Systems*, Vol. IV, Meteorological Measurements, Ver. 2.0, EPA-454/B-08-002 (revised 2008). Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711.

Goff, J. A. and S. Gratch, 1946: Low-pressure properties of water from -160° to 212°F, *Trans. Amer. Soc. Heat. Vent. Eng.*, **51**, 125-164.

Lowe, P. R., 1977: An approximating polynomial for the computation of saturation vapour pressure, *J. Appl. Meteor.*, **16**, 100-103.

Weiss, A., 1977: Algorithms for the calculation of moist air properties on a hand calculator, *Amer. Soc. Ag. Eng.*, **20**, 1133-1136.

WMO, 2008. *Guide to Meteorological Instruments and Methods of Observation*. World Meteorological Organization No. 8, 7th edition, Geneva, Switzerland.

Appendix A. Importing Short Cut Code Into CRBasic Editor

This tutorial shows:

- How to import a *Short Cut* program into a program editor for additional refinement

- How to import a wiring diagram from *Short Cut* into the comments of a custom program

Short Cut creates files, which can be imported into *CRBasic Editor*. Assuming defaults were used when *Short Cut* was installed, these files reside in the C:\campbellsci\SCWin folder:

- .DEF (wiring and memory usage information)
- .CR2 (CR200(X)-series datalogger code)
- .CR300 (CR300-series datalogger code)
- .CR6 (CR6-series datalogger code)
- .CR8 (CR800-series datalogger code)
- .CR1 (CR1000 datalogger code)
- .CR3 (CR3000 datalogger code)
- .CR5 (CR5000 datalogger code)
- .CR9 (CR9000(X) datalogger code)

Use the following procedure to import *Short Cut* code and wiring diagram into *CRBasic Editor*.

1. Create the *Short Cut* program following the procedure in Section 4, *QuickStart* (p. 2). Finish the program and exit *Short Cut*. Make note of the file name used when saving the *Short Cut* program.

2. Open *CRBasic Editor*.

3. Click **File** | **Open**. Assuming the default paths were used when *Short Cut* was installed, navigate to C:\CampbellSci\SCWin folder. The file of interest has the .CR2, .CR300, .CR6, .CR8, .CR1, .CR3, .CR5, or .CR9 extension. Select the file and click **Open**.

4. Immediately save the file in a folder different from C:\Campbellsci\SCWin, or save the file with a different file name.

NOTE	Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the datalogger program. Change the name of the program file or move it, or *Short Cut* may overwrite it next time it is used.

5. The program can now be edited, saved, and sent to the datalogger.

6. Import wiring information to the program by opening the associated .DEF file. Copy and paste the section beginning with heading "-Wiring for CRXXX–" into the CRBasic program, usually at the head of the file. After pasting, edit the information such that an apostrophe (') begins each line. This character instructs the datalogger compiler to ignore the line when compiling.

Appendix B. Example Programs

The following example can be used directly with CR800 series, CR1000, CR3000, and CR5000 dataloggers.

CRBasic Example B-1. CR1000 Program Measuring the EE181

```
'Program measures EE181 with single-ended inputs once every 5 seconds
'and stores the average temperature and a sample of the relative
'humidity every 60 minutes.
'Wiring Diagram
'==============
'EE181
'Wire CR1000
'Colour: Function - Terminal
'------ -------- --------
'Red: Power - SW12
'Yellow: Temperature signal - SE1
'Blue: Relative Humidity signal - SE2
'Black: Power Ground - Ground Symbol
'Clear: Shield - Ground Symbol

Public AirTC : Units AirTC = °C
Public RH : Units RH = %

DataTable(Temp_RH,True,-1)
  DataInterval(0,60,Min,0)
  Average(1,AirTC,FP2,0)
  Sample(1,RH,FP2)
EndTable

BeginProg
  Scan(5,Sec,1,0)
    PortSet(9,1) 'Turn on switched 12V
    Delay(0,2,Sec) '2-second delay
    'EE181 Temperature & Relative Humidity Sensor measurements AirTC and RH:
    VoltSe(AirTC,1,mV2500,1,0,0,_60Hz,0.1,-40)
    VoltSe(RH,1,mV2500,2,0,0,_60Hz,0.1,0)
    PortSet(9,0) 'Turn off switched 12V
    CallTable(Temp_RH)
  NextScan
EndProg
```

The following example can be used directly with the CR6 datalogger.

CRBasic Example B-2. CR6 Program Measuring the EE181

```
'Program measures EE181 with single-ended inputs once every 5 seconds
'and stores the average temperature and a sample of the relative
'humidity every 60 minutes.
'Wiring Diagram
'==============
'EE181
'Wire CR6
'Colour: Function - Terminal
'------ -------- --------
'Red: Power - SW12-1
'Yellow: Temperature signal - U1
'Blue: Relative Humidity signal - U2
'Black: Power Ground - Ground Symbol
'Clear: Shield - Ground Symbol

Public AirTC : Units AirTC = °C
Public RH : Units RH = %

DataTable(Temp_RH,True,-1)
  DataInterval(0,60,Min,0)
  Average(1,AirTC,FP2,0)
  Sample(1,RH,FP2)
EndTable

BeginProg
  Scan(5,Sec,1,0)
    SW12 (1,1 ) 'Turn on switched 12V
    Delay(0,2,Sec) '2-second delay
    'EE181 Temperature & Relative Humidity Sensor measurements AirTC and RH:
    VoltSe(AirTC,1,mV1000,U1,0,0,60,0.1,-40)
    VoltSe(RH,1,mV1000,U2,0,0,60,0.1,0)
    SW12 (1,0 ) 'Turn off switched 12V
    CallTable(Temp_RH)
  NextScan
EndProg
```

Appendix C. Absolute Humidity

The EE181 measures relative humidity. Relative humidity is defined by the equation below:

$$RH = \frac{e}{e_s} \bullet 100 \qquad\qquad (C\text{-}1)$$

where RH is relative humidity, e is vapour pressure in kPa , and e_s is saturation vapour pressure in kPa. Vapour pressure, e, is an absolute measure of the amount of water vapour in the air and is related to the dewpoint temperature. Saturation vapour pressure is the maximum amount of water vapour that air can hold at a given air temperature. The relationship between dewpoint and vapour pressure, and air temperature and saturation vapour pressure are given by Goff and Gratch (1946), Lowe (1977), and Weiss (1977). Relative humidity is relative to saturation above water, even below freezing point. This is why these sensors should not measure 100% RH below zero degrees C, as described in Appendix C.1, *Measurement Below 0 °C (p. C-3)*.

When the air temperature increases, so does the saturation vapour pressure. Conversely, a decrease in air temperature causes a corresponding decrease in saturation vapour pressure. It follows then from Eq. (C-1) that a change in air temperature will change the relative humidity, without causing a change absolute humidity.

For example, for an air temperature of 20 °C and a vapour pressure of 1.17 kPa, the saturation vapour pressure is 2.34 kPa and the relative humidity is 50%. If the air temperature is increased by 5 °C and no moisture is added or removed from the air, the saturation vapour pressure increases to 3.17 kPa and the relative humidity decreases to 36.9%. After the increase in air temperature, there is more energy to vaporize the water. However, the actual amount of water vapour in the air has not changed. Thus, the amount of water vapour in the air, relative to saturation, has decreased.

Because of the inverse relationship between relative humidity and air temperature, finding the mean relative humidity is often not useful. A more useful quantity is the mean vapour pressure. The mean vapour pressure can be computed by the datalogger program as shown in the following examples.

CRBasic Example C-1. CR1000 Program that Computes Vapour Pressure and Saturation Vapour Pressure

```
'Program measures EE181 with single-ended inputs once every 5 seconds
'and stores the average temperature and a sample of the relative
'humidity every 60 minutes.

'Wiring Diagram
'==============
'EE181
'Wire CR1000
'Colour: Function - Terminal
'------ -------- --------
'Red: Power - SW12
'Yellow: Temperature signal - SE1
'Blue: Relative Humidity signal - SE2
'Black: Power Ground - Ground Symbol
```

```
'Clear: Shield - Ground Symbol

Public AirTC : Units AirTC = ˚C
Public RH : Units RH = %
Public e_Sat : Units e_Sat = kPa
Public e_kPa : Units e_kPa = kPa

DataTable(Temp_RH,True,-1)
  DataInterval(0,60,Min,0)
  Average(1,AirTC,FP2,0)
  Sample(1,RH,FP2)
  Sample(1,e_kPa,IEEE4)
EndTable

BeginProg
  Scan(5,Sec,1,0)
    PortSet(9,1) 'Turn on switched 12V
    Delay(0,2,Sec) '2-second delay
    'EE181 Temperature & Relative Humidity Sensor measurements
    'AirTC and RH:
    VoltSe(AirTC,1,mV2500,1,0,0,_60Hz,0.1,-40.0)
    VoltSe(RH,1,mV2500,2,0,0,_60Hz,0.1,0)
    PortSet(9,0) 'Turn off switched 12V
    'Calculate Saturation Vapour Pressure
    SatVP(e_Sat, AirTC)
    'Compute Vapour Pressure, RH must be a fraction
    e_kPa = e_Sat * RH/100
    CallTable(Temp_RH)
  NextScan
EndProg
```

CRBasic Example C-2. CR6 Program that Computes Vapour Pressure and Saturation Vapour Pressure

```
'Program measures EE181 with single-ended inputs once every 5 seconds
'and stores the average temperature and a sample of the relative
'humidity every 60 minutes.

'Wiring Diagram
'==============
'EE181
'Wire CR6
'Colour: Function - Terminal
'------ -------- --------
'Red: Power - SW12-1
'Yellow: Temperature signal - U1
'Blue: Relative Humidity signal - U2
'Black: Power Ground - Ground Symbol
'Clear: Shield - Ground Symbol

Public AirTC : Units AirTC = ˚C
Public RH : Units RH = %
Public e_Sat : Units e_Sat = kPa
Public e_kPa : Units e_kPa = kPa

DataTable(Temp_RH,True,-1)
  DataInterval(0,60,Min,0)
  Average(1,AirTC,FP2,0)
  Sample(1,RH,FP2)
  Sample(1,e_kPa,IEEE4)
EndTable

BeginProg
  Scan(5,Sec,1,0)
    SW12 (1,1 ) 'Turn on switched 12V
    Delay(0,2,Sec) '2-second delay
```

```
    'EE181 Temperature & Relative Humidity Sensor measurements
    'AirTC and RH:
    VoltSe(AirTC,1,mV1000,U1,0,0,60,0.1,-40.0)
    VoltSe(RH,1,mV1000,U2,0,0,60,0.1,0)
    SW12 (1,0 ) 'Turn off switched 12V
    'Calculate Vapour Pressure
    'Calculate Saturation Vapour Pressure
    SatVP(e_Sat, AirTC)
    'Compute Vapour Pressure, RH must be a fraction
    e_kPa = e_Sat * RH/100
    CallTable(Temp_RH)
  NextScan
EndProg
```

C.1 Measurement Below 0 °C

The EE181 provides a humidity reading that is referenced to the saturated water vapour pressure above liquid water, even at temperatures below 0 °C, where ice might form. This is the common way to express relative humidity and is as defined by the World Meteorological Organization. If an RH value is required referenced to ice, the EE181 readings will need to be corrected.

One consequence of using water as the reference is that the maximum humidity that will normally be output by the sensor for temperatures below freezing is as follows:

100%RH at 0 °C	82%RH at –20 °C
95%RH at –5 °C	78%RH at –25 °C
91%RH at –10 °C	75%RH at –30 °C
87%RH at –15 °C	

In practical terms this means that, for instance, at –20 °C the air is effectively fully saturated when the sensor outputs 82% RH.

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